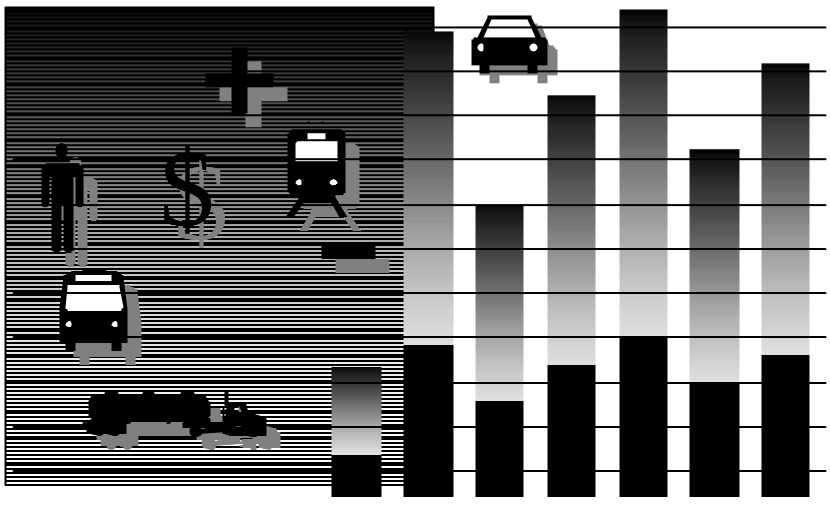
Caltrans

California
Department
Of
Transportation

California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)

User's Guide



Booz·Allen & Hamilton Inc.
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TABLE OF CONTENTS

Welcome to the California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) User's Guide developed for the California Department of Transportation (Caltrans). This quick-start manual introduces you to important features of Cal-B/C and leads you through the analysis of a hypothetical project. The technical supplement to the user’s guide provides details of the methodologies and analytical framework for the model.

Cal-B/C is a spreadsheet-based tool to prepare an analysis of both highway and transit projects. The user inputs data defining the type, scope, and cost of a project. The model then calculates its life-cycle cost, net present value, benefit/cost ratio, internal rate of return, payback period, and itemizes the first-year and life-cycle benefits.

1. User Requirements

At a minimum, the user of Cal-B/C should have a working knowledge of spreadsheets, particularly Microsoft Excel. To use this guide, the reader must be able to navigate through a multiple-sheet workbook and understand basic principles, functions, and the terminology used when discussing spreadsheets.

The professional using the model to analyze projects should also understand life-cycle benefit-cost analysis and be able to interpret the results from such an analysis in a transportation planning context. The reader should refer to the User's Guide Technical Supplement to learn more about the concepts used to develop Cal-B/C.

2. Operating System Requirements

Cal-B/C is a Microsoft Excel 95 spreadsheet called *Cal-BC.xlt*. The file is just under 540,000 kilobytes in size and has been saved as a template to avoid accidental changes to the modal. Although designed for a PC environment, Cal-B/C also works on an Apple Macintosh computer running Excel 5.0/95. The computer operating system must have enough memory and hard disk space to operate Excel and Cal-B/C.

3. Model Overview

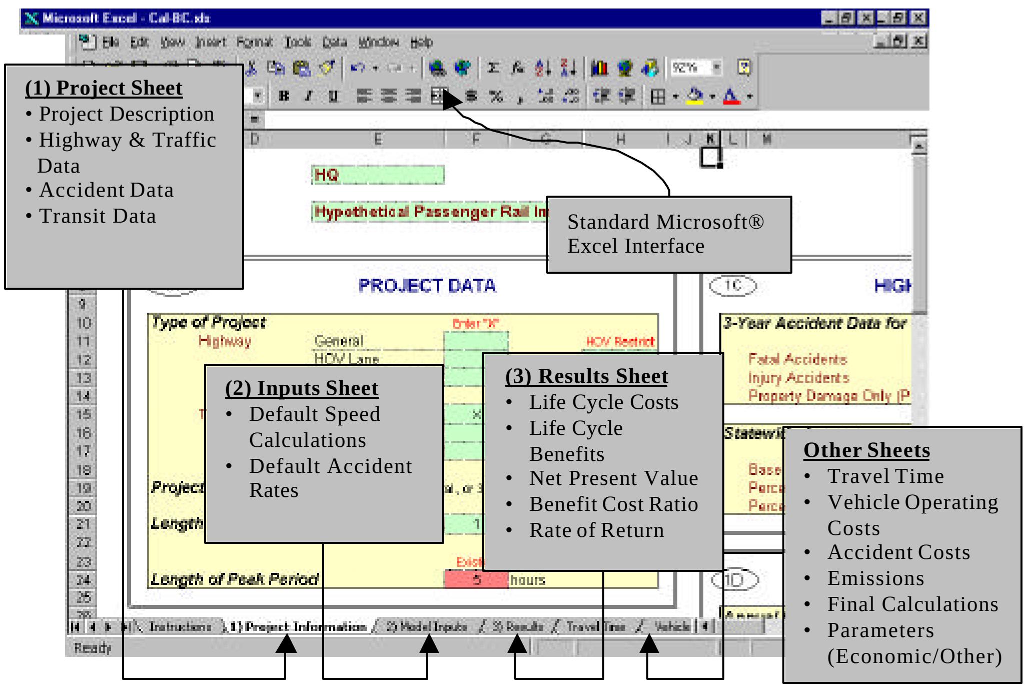
Cal-B/C provides economic benefit and cost analysis for a range of transportation projects. The model consists of ten (10) sheets in an Excel workbook. The user only needs to refer to three (3) of the worksheets to conduct an analysis. An additional sheet provides instructions and reference materials for the user. The six remaining worksheets perform calculations or store default data inputs and economic parameters. The pages that follow describe these sheets in more detail.

Cal-B/C is an "open" model. This means that the user can override default parameters to produce tailored results that are more accurate. The model requires inputs on only three of the worksheets, but the more experienced user can access all worksheets to change default values as needed for the analysis.

Cal-B/C requires relatively few user inputs. Cells in the spreadsheets are color-coded. Green cells represent required data where the user must input a value in order for the model to work. Red cells provide default values, such as average vehicle occupancy, that the user can change if needed. Blue cells represent data items calculated by the model, but that the user can change since some projects have more data available for analysis than do others.

Exhibit 1 shows the Excel user interface for Cal-B/C. The user conducts an analysis using three principal worksheets. The remaining sheets perform calculations automatically or store model parameters.

Exhibit 1: Cal-B/C Graphical User Interface



The first worksheet in the model is the **Instructions** sheet. The user can print this sheet for easy reference. The instructions include short descriptions of each step involved in performing a basic analysis and provide helpful hints about how to avoid potential pitfalls.

The **Project Information** sheet is the main data entry worksheet. Here the user enters descriptive information about the project, expected traffic demand, accident rates, transit data (if the project is a transit project), and expected project construction and operating costs. The sheet also has a button that allows the user to run analyses for bypass and interchange projects that require the user to evaluate more than one road.

Model Inputs contains information about highway speed, volume, and accident data. This sheet allows users to check the highway inputs calculated by the model and override the calculated values by using project-specific information, if such information is available. Some users may have volume and speed estimates and projections from regional travel demand forecasting models. The user can use peak and off-peak period volumes and speeds from the travel demand model to override the calculated values produced by Cal-B/C. The model calculates speeds based on speed/volume relationships found in the 1997 Highway Capacity Manual.

The **Results** sheet presents the final investment measures, including:

- Life-Cycle Costs
- Life-Cycle Benefits
- Net Present Value
- Benefit-to-Cost Ratio
- Rate of Return on Investment
- Payback Period.

The model also itemizes the anticipated benefits (in millions of dollars) for Year 1 (defined as the first year <u>after</u> construction of the project has been completed) and for the full twenty-year life cycle. The calculated benefits include:

- Travel Time Savings
- Vehicle Operating Cost Savings
- Accident Reductions
- Emission Reductions.

The Results sheet allows the user to include the effects of *induced travel* and *vehicle emissions*. Cal-B/C calculates induced travel benefits using consumer surplus theory, as described in the technical supplement. Induced travel refers to the demand for travel generated by the project. For example, a project may reduce congestion that had previously kept some people from traveling. The model asks users whether to include induced travel in the analysis. The model default is "Y," meaning "Yes, include induced demand in the model." Users must include induced travel in the model inputs. If the highway volume inputs do not include induced travel, answering “Y” or “N” does not affect the benefit calculations.

The vehicle emissions option prompts the model to include an estimate of emission changes due to the project. The default value in the model is "N" meaning, "No, Do not perform an analysis of emissions costs."

There are six additional worksheets, which calculate model results or store default values for the model. These sheets include:

Travel Time calculates total travel time and induced demand benefits on highway and transit. Modes analyzed in the model include HOV highway, non-HOV highway, truck, passenger rail, light rail, and bus.

Vehicle Operating Costs calculates changes in highway vehicle operating costs as benefits for highway and transit projects.

Accident Costs calculates benefits due to accident reductions for highway and transit vehicles.

Emissions calculates benefits due to emissions reductions for highway and transit vehicles. The model default option is "N" (no analysis).

Final Calculations completes the analysis before presenting the summary results. This sheet calculates net present value, internal rate of return on investment, and payback period.

Parameters contains all the economic values and rate tables used by the model. Adjusting the *Economic Update Factor* using the Gross Domestic Product (GDP) deflator changes the economic values contained in the model. Values in this sheet include the following unit costs:

- General economic values
- Highway operations measures
- Travel time values
- User operating costs
- Highway accident costs
- Fuel consumption rates
- Transit accident rates and costs
- Highway and transit emissions tables.

The user should update these parameters as up-to-date research becomes available.

The three main data entry worksheets are described below. For detailed information on the parameter worksheets, please refer to the technical supplement to the User's Guide, which describes the methodology used to develop Cal-B/C.

4. Worksheet Details and Project Analysis

The following sections describe the three primary Cal-B/C worksheets and walk the user through a hypothetical project. The main text in each section introduces the user to an element of the model and the project examples provide details on how to enter data.

4.1 Project Information Worksheet

The *Project Information* sheet is the main data input sheet (Exhibit 2). For most projects, this will be the only sheet needed by the user. The user needs to modify other sheets only if the user has information more specific to the project than is calculated by the model. The project information worksheet has five sections identified in Exhibit 2 and in the table below. A button is available to prepare the model to analyze a bypass road or the crossing road for an interchange project.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
1A	Project Data	B6:I26
1B	Highway Design and Traffic Data	B28:I53
1C	Highway Accident Data	K6:Q20
1D	Transit Data	K22:Q26
1E	Project Costs	T6:AE49
	Bypass/Interchange Button	K47:Q53

4.1A Project Data

The project data input section, as shown in Exhibit 3, is where the user enters the following types of information about the project:

Type of project. The model allows the user to identify several project types including:

Highway	Transit
HOV and Passing Lanes	Passenger Rail
Interchanges	Light-Rail (LRT)
Bypasses	Bus
Other	

Project location (e.g., Northern California Urban, Southern California Urban, or rural). The model uses this information to estimate emission benefits.

Length of construction period determines the opening date of the project in order to apply the correct economic growth factors.

Length of peak period(s) helps the model determine peak speeds. Cal-B/C uses peak speeds to estimate user costs, fuel consumption, and emissions.

Exhibit 2: Project Information Worksheet

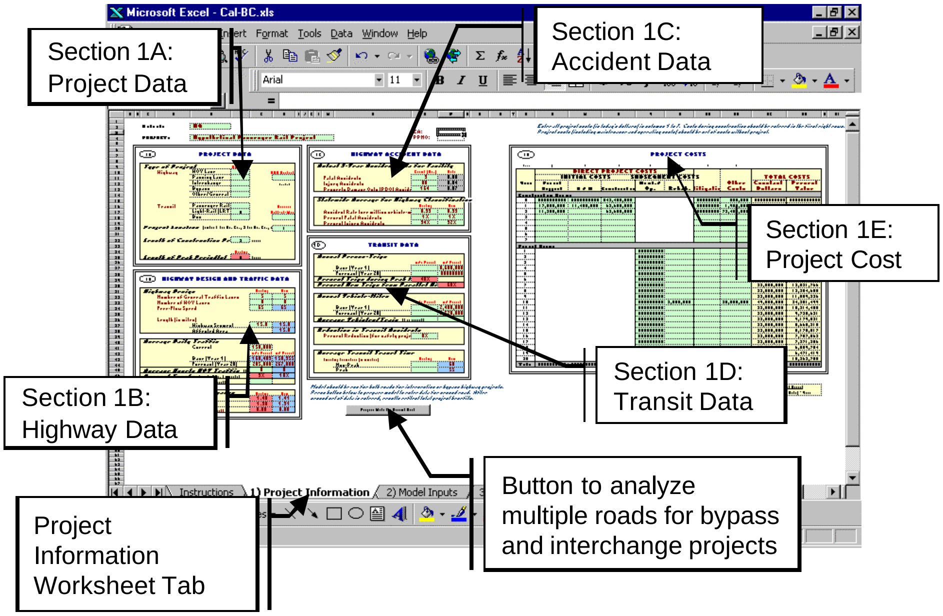
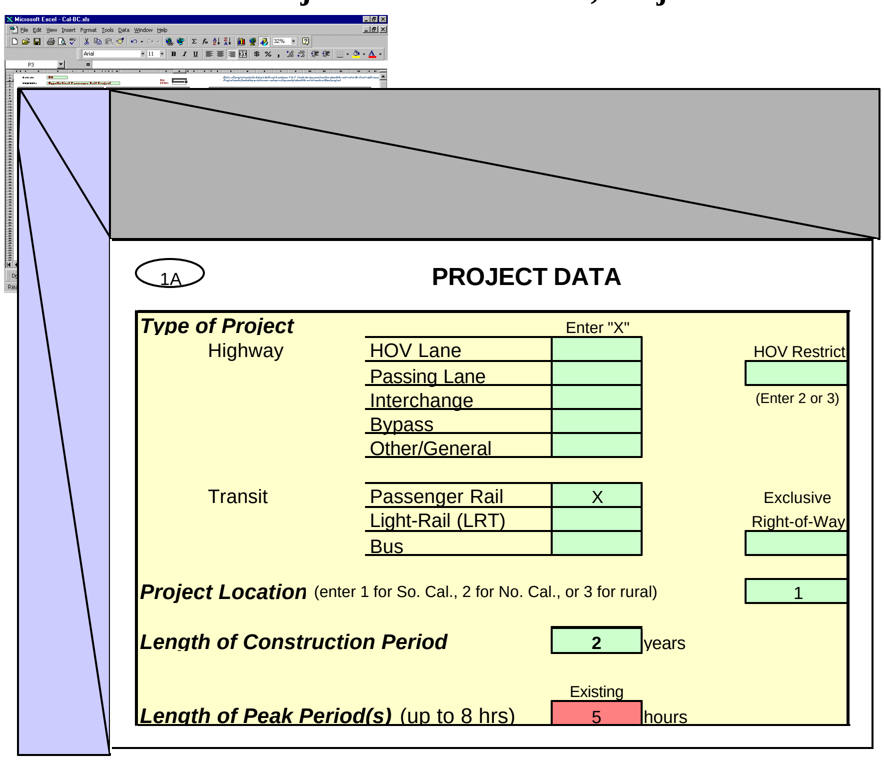


Exhibit 3: Project Information - 1A, Project Data



Project Example - Passenger Rail Improvement: Entering Project Information

Open the *Project Information* sheet to begin an analysis. Exhibit 3 shows the *Project Data* section for a passenger rail improvement project. Green cells are cells that require data input. The red cells provide default values that the user can change.

(1) **Type of Project**. Put an "X" in the cell to the right of the "Passenger Rail" legend. You are required to enter the "X" in all of the cells that can be used to describe the type of project. Since this project is only for a rail project, it is not necessary to enter the other project type cells.

There are two project types requiring special attention: *HOV Lane Additions* and *Bus Transit*. If you are evaluating an HOV lane project, you must enter an HOV Restriction in the cell to the right of the HOV Lane project type. Only two values are accepted by the model: a "2" or "3". A value of "2" represents a two-person carpool restriction, and a "3" is a three or more person restriction. The model accounts for the fact that some carpools using a two-person HOV lane will carry more than two people and that some three-person carpools carry more than three people. Default average vehicle occupancy rates used in Cal-B/C come from the *1991 Statewide Travel Demand Survey* conducted by Caltrans.

For *Bus Transit projects*, you must enter a "Y" (for "Yes") or "N" (for "No") to indicate if the buses will operate on a dedicated right-of-way. The model uses the information in this cell to determine transit operating speeds and to estimate the improvement in speeds on other traffic lanes due to transit services.

(2) **Project Location**. This cell requires you to enter a "1" for Southern California urban areas, a "2" for Northern California urban areas, or a "3" for rural areas in order to determine emissions benefits for the project. Assume that our project is being built in Southern California, and put a "1" in this cell. This cell tells the model which emissions tables to reference in the Emissions worksheet.

(3) **Length of Construction Period**. Enter the amount of time needed to construct the project. Assume that our rail project will be completed in 2 years. The model evaluates project impacts only after the project is built. For example, a project begun in 2000 that takes five years to complete would not cause any impacts until year 2005 when the project opens. The Year 1 impacts occur immediately after the project opens. The Year 20 impacts would occur in 2024 for this hypothetical project. Cal-B/C uses this cell to determine the economic impacts. This number must be a whole number. For example, a project that will take 8 months to construct should be entered as the number "1" representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years, at the user's discretion, but must be consistent with the cost data entered.

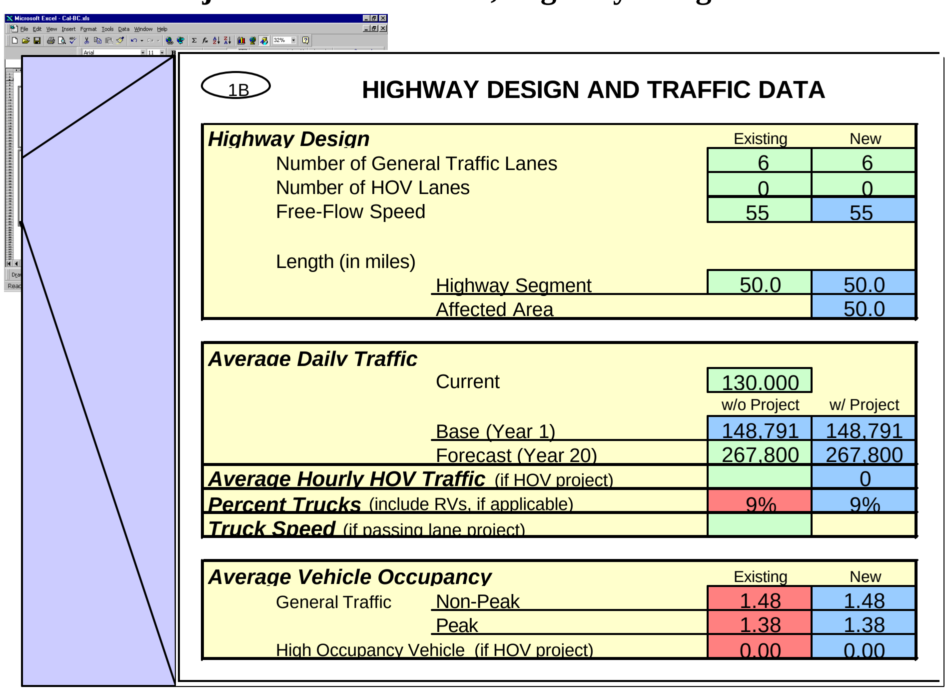
(4) **Length of Peak Period**. For our project, enter a "5" in this cell to represent a five-hour total daily peak travel period (include both AM and PM peak periods). The model allows the user to evaluate up to an eight (8) hour daily peak period. Cal-B/C calculates peak hour traffic by multiplying a statewide average peak-hour percent traffic by the number of peak hours. In Cal-B/C this is calibrated to five hours. Peak periods greater than eight (8) hours will produce erroneous results. The user must adjust the length of the peak period and the percent ADT in a typical peak hour (entered in Parameters sheet) for projects with peak periods longer than 8 hours. The peak period helps convert average daily traffic volumes (described below in Section 4.1B) into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

4.1B Highway Design and Traffic Data

This section, shown in Exhibit 4, allows the user to input information about the highway components for both highway and transit projects. The user inputs the transit elements of the project in another section. Here, the user enters data for the existing or "No Build" situation and for the future or "Build" situation after project completion. The following sections are used to enter the appropriate data:

- Highway Design
  - Number of general traffic and HOV lanes
  - Free-flow speed
  - Segment length and affected length
- Average Daily Traffic for current, base (project opening), and forecast years
- Average Hourly HOV traffic (HOV projects only)
- Percent Trucks (including recreational vehicles [RV's])
- Truck Speed (truck lane or passing lane projects only)
- Average Vehicle Occupancy for peak, non-peak, and HOV lanes.

Exhibit 4: Project Information - 1B, Highway Design & Traffic Data



1B HIGHWAY DESIGN AND TRAFFIC DATA

		Existing	New
Highway Design			
Number of General Traffic Lanes		6	6
Number of HOV Lanes		0	0
Free-Flow Speed		55	55
Length (in miles)			
	Highway Segment	50.0	50.0
	Affected Area		50.0

Average Daily Traffic			
	Current	130,000	
		w/o Project	w/ Project
	Base (Year 1)	148,791	148,791
	Forecast (Year 20)	267,800	267,800
Average Hourly HOV Traffic (if HOV project)			0
Percent Trucks (include RVs, if applicable)		9%	9%
Truck Speed (if passing lane project)			

		Existing	New
Average Vehicle Occupancy			
General Traffic	Non-Peak	1.48	1.48
	Peak	1.38	1.38
High Occupancy Vehicle (if HOV project)		0.00	0.00

Project Example - Passenger Rail Improvement: Entering Highway Design and Traffic Data

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit 4).

(1) **Highway Design**. Assume that the highway parallel to the rail project has six (6) general traffic lanes and no HOV lanes in both directions (i.e., three lanes per direction) Set the free-flow speed to 55 mph. Make sure that the "New" number of lanes is the same as the "Existing" number. Otherwise, the model will not produce the correct results for this rail project (A lane addition project requires that the "New" number of lanes be greater than the "Existing" number). The model does not allow the user to "phase in" the construction. For example, you cannot construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.

The blue cell for the "New" project free-flow speed will be set automatically to the "Existing" free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in the forecast year is different from the current free-flow speed.

The *Length* cells determine the distance that the project will influence. In our example, assume that the project is an interregional rail project along a 50-mile corridor. The *Affected Area* only applies to passing lane projects. This is because adding a truck climbing or passing lane not only improves traffic flow on the segment where the lane is located, but also affects traffic upstream of the new lane. Cal-B/C assumes the default value for the affected area is three miles longer than the highway segment length. However, you may change this value if you believe the distance affected by a passing lane is different from the three-mile default.

(2) **Average Daily Traffic**. Enter the existing average daily traffic into the cell labeled "current." Use a value of 130,000 for this exercise. Also, enter a value of 267,800 vehicles per day for the forecast year.

Note: The forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

The model calculates the "Base (Year 1)" value in the "without project" column. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. If you have data that are more accurate for Year 1, you can override the values calculated by the model.

Notice that the "without project" and "with project" scenario volumes are the same for the passenger rail project. The model requires the user to assume a constant volume for highway demand, UNLESS demand on the highway is expected to increase because of the rail project. We take the shift from highway to rail into account when we input the transit information. The model will correctly calculate the benefits associated with mode shifts to rail although it is not apparent on this input screen.

Note: The *Results* sheet has an option to include induced demand in the evaluation. If "Y" for "Yes" is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with project scenario compared to the without project scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

(3) **Average Hourly HOV Traffic**. Update these cells only if this is an HOV project. As with the average daily traffic cells, these cells require the "without project" number of HOV lanes and the future number of HOV lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.

(4) **Percent Trucks**. Enter the percent truck composition of the traffic stream here. The model assumes a nine (9) percent truck composition for both the "with" and "without" project scenarios.

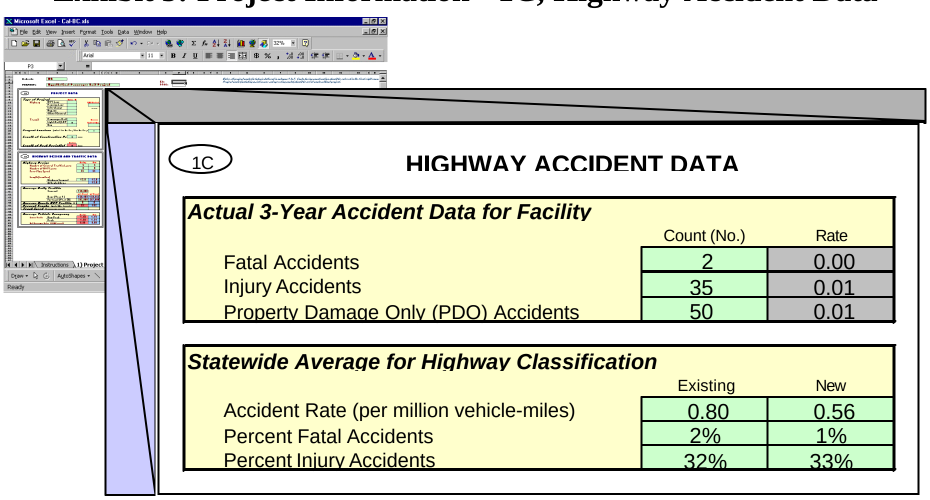
(5) **Truck Speed**. We do not need this information for our passenger rail project. For passing lane projects, trucks travel this speed on a grade when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using volume/capacity relationships provided in the most recent Highway Capacity Manual. Trucks may have a much slower speed on grades where a passing lane project is to be constructed. Leave this cell empty for our project.

(6) **Average Vehicle Occupancy (AVO)**. This is the average number of people per vehicle on the highway. Let us use the model default (from the 1991 Statewide Travel Survey) of 1.48 for the non-peak AVO and 1.38 for the peak AVO for the "Existing" scenario. Assume a slight reduction in AVO in the "New" scenario to 1.41 in the off-peak and 1.31 in the peak as travelers use transit more.

4.1C Highway Accident Data

This section calculates accident rates for the highway facility as shown in Exhibit 5. Accident rates are estimated for fatalities, injuries, and property damage only accidents. For transit projects, the "Count" column contains default values based on statewide averages. For highway projects, the user should override these values with data specific to the segment. The accident rate column, highlighted in gray, is calculated and should not be edited. The calculated value is simply the annualized count divided by millions of vehicle miles (average daily traffic x segment length x 365 days/1,000,000).

Exhibit 5: Project Information - 1C, Highway Accident Data


1C HIGHWAY ACCIDENT DATA

Actual 3-Year Accident Data for Facility	Count (No.)	Rate
Fatal Accidents	2	0.00
Injury Accidents	35	0.01
Property Damage Only (PDO) Accidents	50	0.01

Statewide Average for Highway Classification	Existing	New
Accident Rate (per million vehicle-miles)	0.80	0.56
Percent Fatal Accidents	2%	1%
Percent Injury Accidents	32%	33%

Project Example - Passenger Rail Improvement: Reviewing Accident Data

The model has the statewide averages already entered in Exhibit 5. Assume, however, that we have some highway accident data and projections available for our project.

(1) In the **Actual 3-Year Accident Data for Facility** cells, assume there were two (2) fatal accidents on the parallel highway corridor over the past three years, 35 injury accidents, and 50 property damage only accidents.

(2) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. Include Base Rate and ADT factors, where applicable. Also, insert statewide percent of accidents that are fatal and injury accidents for road classifications similar to existing and proposed facilities. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents the results, which the user can edit.

For our project, assume that overall accident rates will decline because of reduced congestion on the roadway (from 0.80 to 0.56). Also assume fatal accidents will decline from 2% to 1% and injury accidents will increase from 32% to 33%.

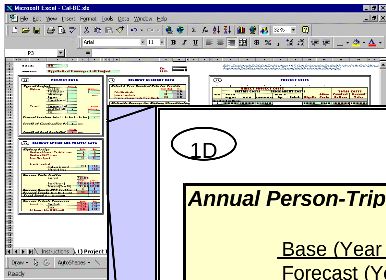
4.1D Transit Data

This section of the project information sheet is used only for transit projects. For transit projects, the user must enter seven additional data items into the model:

- Annual person-trips
- Percent of person-trips occurring during the peak period
- Percent of new person-trips that are from the parallel highway
- Annual vehicle-miles
- Average vehicles per train (if it is a rail project)
- Reduction in transit accidents due to the project (if it is a safety project)
- Average transit travel time (including transfers and wait times).

Exhibit 6 shows the transit data input section of the project information sheet.

Exhibit 6: Project Information - 1D, Transit Data



1D

TRANSIT DATA

Annual Person-Trips		
	w/o Project	w/ Project
Base (Year 1)	310,000	400,000
Forecast (Year 20)	460,000	600,000
Percent Trips during Peak Period	60%	
Percent New Trips from Parallel Highway		65%

Annual Vehicle-Miles		
	w/o Project	w/ Project
Base (Year 1)	532,000	740,000
Forecast (Year 20)	532,000	740,000
Average Vehicles/Train (if rail project)	3	4

Reduction in Transit Accidents	
Percent Reduction (for safety projects)	5%

Average Transit Travel Time		
Including transfers (in minutes)	Existing	New
Non-Peak	50	45
Peak	50	45

Project Example - Passenger Rail Improvement: Entering Transit Data

Here is where we do most of our data entry for our rail project. Assume that we are implementing a project to improve train safety, travel times, and frequency of service. Such a project may require some right-of-way improvements, signaling improvements, and additional passenger train cars.

(1) **Annual Person Trips**. As in step 3, when we entered average daily traffic for the parallel highway, we input base year (Year 1) and forecast year (Year 20) estimates for transit demand. Input the demand data as shown in Exhibit 6.

(2) **Percent during Peak Period**. This is where you estimate the ratio of peak period to daily ridership. In our example, assume that 60% of all transit trips on the line will occur during the five-hour peak period.

(3) **Percent New Trips from Parallel Highway**. Typically, improved passenger rail services attract some new trips from parallel highways. In practice, the percentage of new transit trips coming from highways falls somewhere between 50% and 80%. Let us assume that our new line will bring 65% of its new passengers from the highway in question.

(4) **Annual Vehicle Miles**. This is the number of vehicle-miles operated on the passenger rail line per year. Assume 532,000 revenue miles for Years 1 and 20 in the "without project" scenario and 740,000 for the "with project" scenario.

(5) **Average Vehicles per Train**. Enter the number of train cars that will be used on an average train consist during the day. In our example, we assume that each train will add an average of 1 car per train during the day increasing from three (3) cars in the "without project" scenario to four (4) for our new project. This means that some trains may have three cars, but others may have 5 or more per consist depending on the demand.

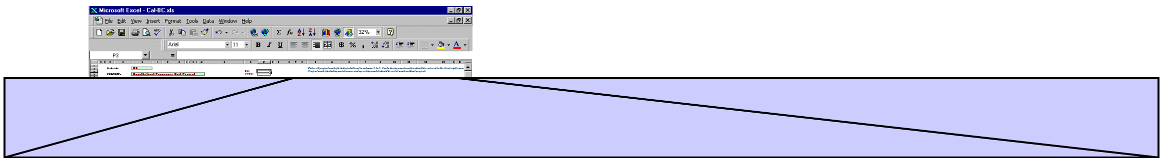
(6) **Reduction in Transit Accidents**. If you are building a safety project, enter the percent reduction in transit accidents that you expect to occur due to the project. Assume that this project includes grade-crossing improvements to increase vehicle and pedestrian safety, and we anticipate a 5% reduction in train incidents.

(7) **Average Transit Travel Time**. This is where you enter the average travel time required to make a trip on transit. The transit travel time represents the total travel time by transit and includes the waiting time for the transit vehicle, transfer times, and the in-transit time. Enter the values as shown in Exhibit 6.

4.1E Project Cost Data

The user enters project construction, operating, mitigation, and other costs in this section of the project information worksheet. Note that all costs are the incremental costs to provide that project. Incremental costs are the difference between costs with the project and the costs without the project. The project costs worksheet contains seven columns for users to enter cost information as shown in Exhibit 7. Three other columns list the project year and sum the costs.

Exhibit 7: Project Information - 1E, Project Costs



1E

PROJECT COSTS

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS							TOTAL COSTS	
	INITIAL COSTS			SUBSEQUENT COSTS					
Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation	Other Costs	Constant Dollars	Present Value
Construction Begins									
0	$500,000	$4,000,000	$6,000,000			250,000		$10,750,000	$10,750,000
1	400,000		6,500,000			500,000		7,400,000	6,981,132
2	200,000		4,000,000			800,000	15,000,000	20,000,000	17,799,929
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
Project Opens									
1				175,000				$175,000	$155,749
2				175,000				175,000	146,933
3				175,000				175,000	138,616
4				175,000				175,000	130,770
5				175,000				175,000	123,368
6				175,000				175,000	116,385
7				175,000				175,000	109,797
8				175,000				175,000	103,582
9				175,000				175,000	97,719
10				175,000			2,000,000	2,175,000	1,145,763
11				175,000				175,000	86,970
12				175,000				175,000	82,047
13				175,000				175,000	77,403
14				175,000				175,000	73,021
15				175,000				175,000	68,888
16				175,000				175,000	64,989
17				175,000				175,000	61,310
18				175,000				175,000	57,840
19				175,000				175,000	54,566
20				175,000	2,500,000			2,675,000	786,866
Total	$1,100,000	$4,000,000	$16,500,000	$3,500,000	$2,500,000	$1,550,000	$17,000,000	$46,150,000	$39,213,644

Adjust Construction Period

Error Message:
Adjust Construction
Period in Section 1A

The sections that follow describe all ten columns.

The first column is the project year starting with Year 0, the current year. The model assumes that the project needs no more than seven years to complete the construction. Following the construction period, the project opens and there are twenty (20) years during the project operating period. Year 1 (Base Year) described in the previous sections is represented by the "1" under the "Project Opens" header. Year 20 (Forecast Year) is represented by the last row on this data entry form. For each row in the section (i.e., each row in the spreadsheet), the user enters the anticipated costs for the year in current year dollars. The model automatically calculates the sum and present value.

Direct Project Costs

Initial costs include:

- Project support (e.g., engineering design and management costs)
- Right-of-Way (R/W) acquisition costs
- Construction costs.

Notice that the project incurs no initial project costs after the project opens. Cal-B/C assumes that all construction funding has been spent by opening day of the project. Furthermore, it is important to note that the user cannot exceed the number of years of construction entered in Section 1A of the project information worksheet. If the user does not enter the construction costs correctly, the model prompts the user for the correct information in the whole zone under subsequent costs. This is illustrated in Exhibit 7.

Subsequent Costs are costs incurred after the project has been constructed and opened for service. These costs include:

- Maintenance and operating costs
- Rehabilitation costs (e.g., pavement overlay, vehicle, track, or station refurbishment).

<u>Other Costs</u>

This column includes all other costs incurred by the project, mitigation costs (e.g., sound barriers or environmental mitigation), and other costs that do not fit or have not been included in the other cost categories.

<u>Total Costs</u>

The remaining two columns are calculated by the model automatically. These two columns include the project cost in constant dollars and the net present value for each year. Each column is summarized at the bottom of the section. The following formula calculates the net present value:

$$\text{Net Present Value} = \frac{\text{FutureValue (in constant dollars)}}{(1+\text{Real Discount Rate})^{\text{Year}}}$$

Project Example - Passenger Rail Improvement: Entering Project Costs

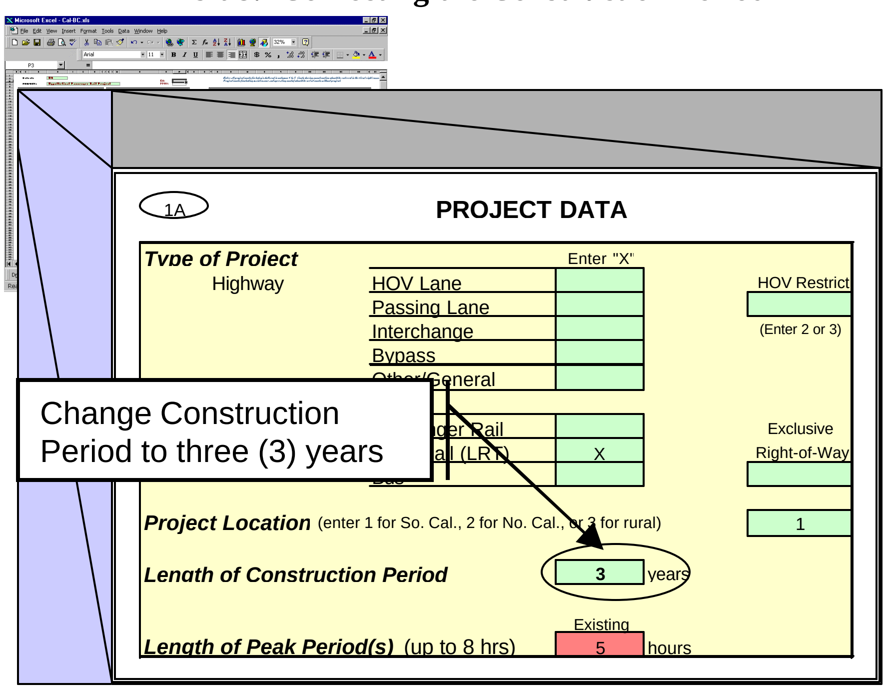
This is the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis.

(1) Enter the **Initial Project Costs**. Enter the project costs for Years 0 through 2 as shown in Exhibit 7. Note the error message received after entering the data for Year 2. It says, "Adjust Construction Period" (Look at the white space under the "SUBSEQUENT COST" columns). Our construction dollars are being spent over three years, yet we indicated in Section 1A of the Project Information worksheet that construction would last only two years. Go back to the Project Information sheet and make the change as shown in Exhibit 8.

(2) Now look at the years after the project has been constructed and is open for service. In our project, we will have to allocate funding to operate and maintain the project. These project maintenance and operating costs are the net costs required to operate the additional service, not the costs to operate the total service on that alignment. If we were to increase service on an existing rail line, we would subtract the cost required to operate the current route (i.e., the "without project" scenario) from the cost to operate the "with project" scenario.

(3) Before reviewing the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of $46.15 million with a net present value of $39.2 million.

Exhibit 8: Correcting the Construction Period



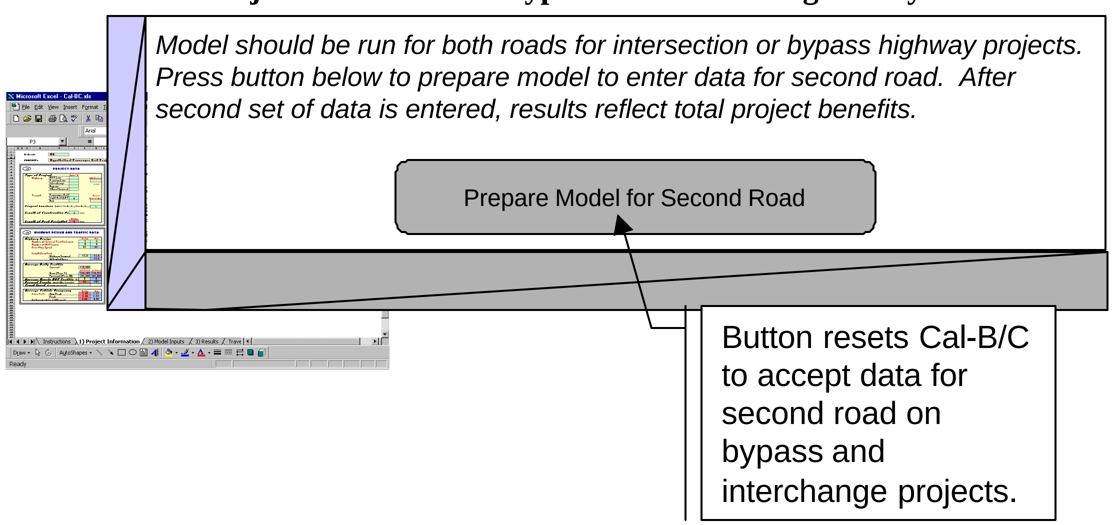
4.1F Bypass and Interchange Projects

Bypass and interchange projects require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before user enters information about the second road. The user clicks the button shown in Exhibit 9. The button then clears the Project Information worksheet to receive information for the second road. Only use the button for bypass and interchange projects. If the user clicks this button for any other type of project, the user must re-open the model and begin the analysis again.

For interchange projects, the button simply clears the highway information box, so that traffic and highway geometric data can be entered for the other (intersecting road). For bypass projects, the model zeros the highway information under the existing/without project column and calculates the with project column traffic on the bypass road as the without project traffic minus the project traffic on the existing roads. The user only needs to enter the highway geometric information (e.g., number of lanes, etc.). For bypass projects, the model automatically changes the green and blue box colors in the highway information box so the user knows what data to enter. For both types of projects, the model retains accident data for the second road, but the user can change this if data specific to second road are available.

After entering data for the first road, the user should check the speeds and volumes in the Model Inputs sheet. The user should return to the Project Information sheet to click the button. It is important to note that the model cannot calculate induced demand for bypass projects.

Exhibit 9: Project Information - Bypass and Interchange Analysis Button



4.2 Model Inputs Worksheet

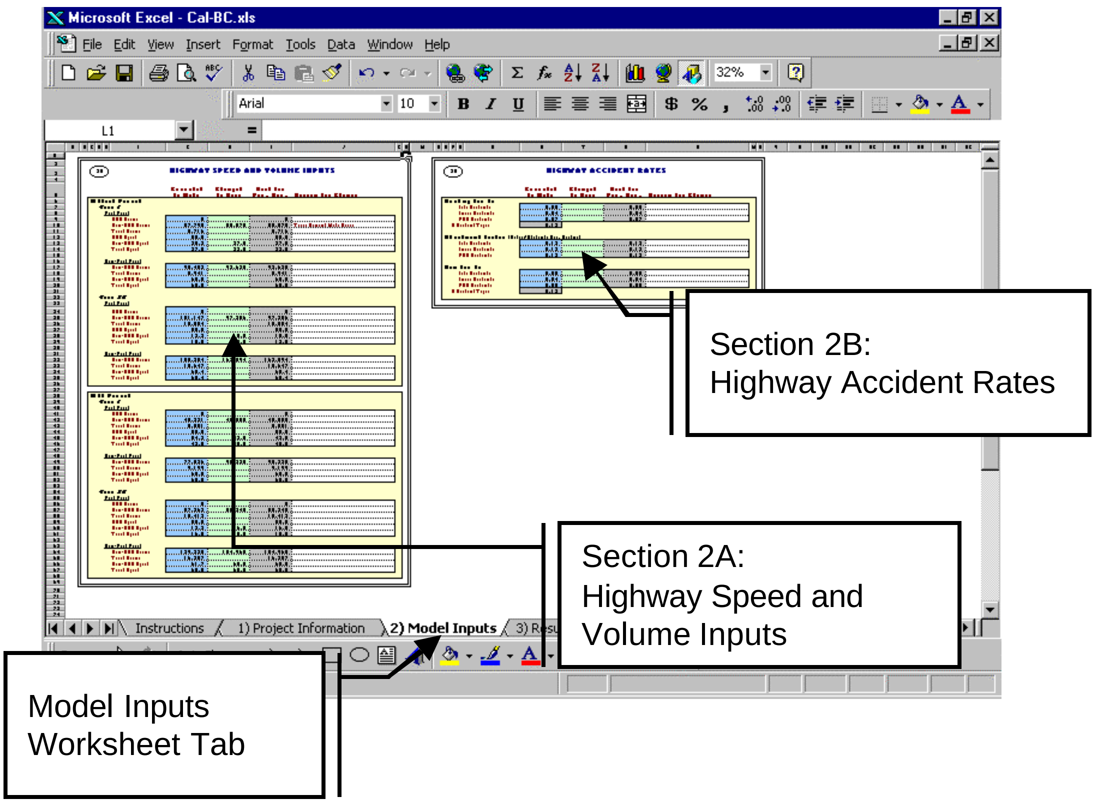
The model inputs worksheet (Exhibit 10) allows the user to override many of the values used to perform the benefit-cost analysis. Many projects have more in-depth data available, such as the output of a regional travel demand model. In these cases, the user should override the Cal-B/C defaults. The model provides two sections in the model inputs worksheet for doing this. Several items are contained within these two sections:

- Highway Speed and Volume Inputs
  - Peak and non-peak periods

– HOV, non-HOV, and truck volumes
– HOV, non-HOV, and truck speeds
- Highway Accident Rates and adjustment factors (existing and new facilities)
  – Fatal accidents
  – Injury accidents
  – Property damage only (PDO) accidents.

The sheet shows the model estimate and provides a space for the user to change the value without disrupting the model defaults. There is also a space provided to input an explanation for the change.

Exhibit 10: Model Inputs Sheet



For example, Cal-B/C forecasts accident rates with the project by calculating the ratio of current accident rates to the statewide average found in the accident data book published by the Traffic Operations Program. If a particular stretch of highway has accident rates above the statewide average, the model will forecast accident rates with project also above the average.

If the project is designed to lower accident rates to the statewide average, the user must manually override the value calculated by the model by changing the accident adjustment factor. The model assumes (through the adjustment factor) that the differential remains the same for the new facility. The user can change this factor to 1.0 if the user thinks that the project will result in accident rates at the statewide average for the facility type. The user can control this calculation separately for fatal accidents, injury accidents, and Property Damage Only (PDO) accidents.

Project Example - Passenger Rail Improvement: Adjusting Model Inputs

We have completed the *Project Information Worksheet*, but assume for our example that we have additional volume information from a regional travel demand model. In particular, we have more detailed estimates of peak and off-peak volumes. In the Model Inputs sheet, the average daily volume is broken out into peak and non-peak volumes as shown in Exhibit 11.

(1) In our **Without Project Peak Period** section type 55,446 in the "Changed by User" field for the Year 1 Non-HOV volume and 5,484 in the truck volume cell (This represents a 2% reduction in volumes as estimated by Cal-B/C. Fill in the remaining cells in the "Changed by User" field in Exhibit 11.

NOTE: The total volume in the "Used for Proj. Eval." field for each section should equal the total volume on the highway.

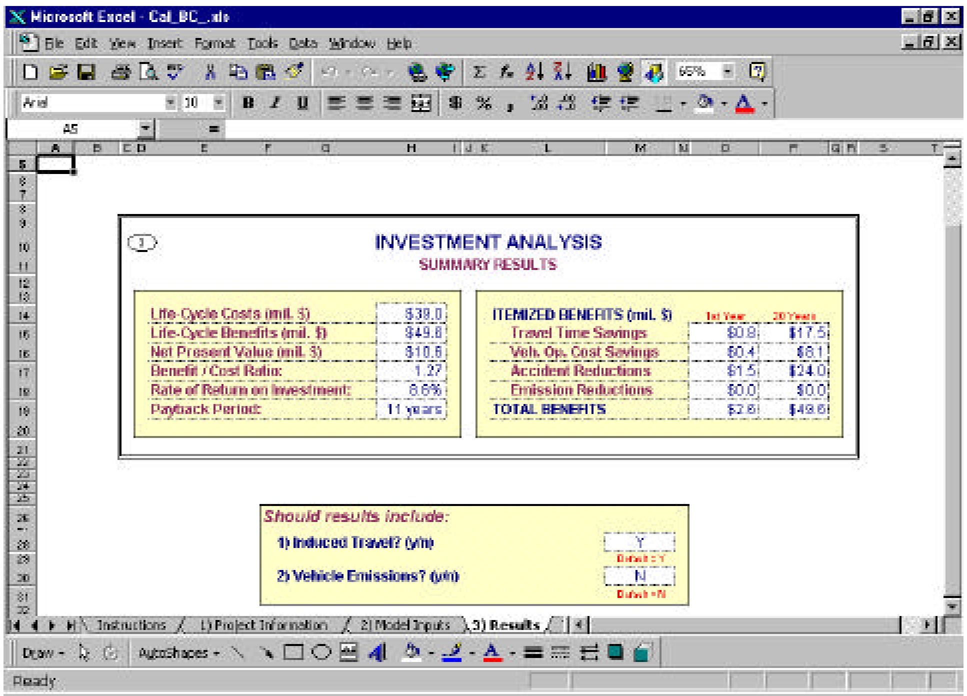
Exhibit 11: Model Inputs - 2A, Update Speed and Volume Inputs

	Calculated by Model	Changed by User	Used for Proj. Eval.
Without Project			
Year 1			
Peak Period			
HOV Volume	0		0
Non-HOV Volume	52,806	55,446	55,446
Truck Volume	5,223	5,484	5,484
HOV Speed	55.0		55.0
Non-HOV Speed	46.8		46.8
Truck Speed	46.8		46.8
Non-Peak Period			
Non-HOV Volume	82,594	79,954	79,954
Truck Volume	8,169	7,907	7,907
Non-HOV Speed	55.0		55.0
Truck Speed	55.0		55.0
Year 20			
Peak Period			
HOV Volume	0		0
Non-HOV Volume	95,042	99,794	99,794
Truck Volume	9,400	9,870	9,870
HOV Speed	55.0		55.0
Non-HOV Speed	10.3		10.3
Truck Speed	10.3		10.3
Non-Peak Period			
Non-HOV Volume	148,656	143,904	143,904
Truck Volume	14,702	14,232	14,232
Non-HOV Speed	54.8		54.8
Truck Speed	54.8		54.8
With Project			
Year 1			
Peak Period			
HOV Volume	0		0
Non-HOV Volume	52,736	55,373	55,373
Truck Volume	5,223	5,484	5,484
HOV Speed	55.0		55.0
Non-HOV Speed	46.9		46.9
Truck Speed	46.9		46.9
Non-Peak Period			
Non-HOV Volume	82,551	79,914	79,914
Truck Volume	8,169	7,907	7,907
Non-HOV Speed	55.0		55.0
Truck Speed	55.0		55.0
Year 20			
Peak Period			
HOV Volume	0		0
Non-HOV Volume	94,934	99,681	99,681
Truck Volume	9,400	9,870	9,870
HOV Speed	55.0		55.0
Non-HOV Speed	10.3		10.3
Truck Speed	10.3		10.3
Non-Peak Period			
Non-HOV Volume	148,588	143,842	143,842
Truck Volume	14,702	14,232	14,232
Non-HOV Speed	54.8		54.8
Truck Speed	54.8		54.8

4.3 Results Worksheet

The final worksheet covered in this User's Guide is the *Results Worksheet*. This is where the user finds the outputs from Cal-B/C. Exhibit 12 shows an example of this output. Note that the Results worksheet asks for an additional input, and that input is to determine if the project will induce demand (i.e., additional travel in the with project case compared to the without project case). If the user selects "Y", then Cal-B/C uses an econometric technique (change in consumer surplus) to value induced demand. Selecting "Y" for emissions calculates net air quality benefits. The default is "N." If either of these toggles is changed for bypass or interchange projects, then the change should be made before the button is pushed to prepare the model for the other road.

Exhibit 12: Results Worksheet - Final Model Output



Cal-B/C summarizes the analysis results on a per-project basis using several measures:

- Life-cycle costs (in $ million)
- Life-cycle benefits (in $ million)
- Net present value (in $ million)
- Benefit/cost ratio (benefits/costs)
- Rate of return on investment (in % return/year)
- Project payback period (in years).

The model calculates these results over the life of the project, which is assumed to be twenty years. In addition, Cal-B/C displays itemized first-year and life-cycle benefits.

Life-Cycle Costs are the present values of all net project costs, including initial and subsequent costs in real current dollars.

Life-Cycle Benefits are the sum of the present value benefits for the project.

Net Present Value equals the Life-Cycle Benefits minus the Life-Cycle Costs. The value of benefits exceeds the value of costs for a project with a positive net present value.

Benefit/Cost Ratio shows the benefits relative to the costs of a project. A project with a benefit/cost ratio greater than one has a positive economic value.

Rate of Return on Investment is the discount rate at which benefits and costs are equal. For a project with a Rate of Return greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The Rate of Return on Investment allows the user to compare projects with different costs, different benefit flows, and different times.

Payback Period is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

Project Example - Passenger Rail Improvement: Review Analysis Results

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit 12).

You are now ready to use Cal-B/C to model standard highway and transit improvement projects. For more information on the model framework or how Cal-B/C estimates particular impacts, please see the technical supplement to the user's manual.